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BER and Q-factor performances of a 60 GHz Millimeter Wave Generation using Narrow-Band Bragg Filters

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Abstract — *In this paper, we study a new technique for millimeter wave generation using a RoF system based on the use of narrow band Bragg filters as reflectors of very specific wavelengths. The proposed system performance depends on various parameters, mainly: optical fiber length, FBG bandwidth, optical power.etc. In our case, the different simulations have been carried out in order to show the effect of the optical fiber length on the eye diagram, the quality factor and the BER values. The obtained results indicate that the proposed system remains efficient for fiber lengths up to 70 Km with a bit rate of 1 Gbit/s and a FBG bandwidth of 10^{-6} nm.*

Keywords — *Millimeter Waves– FBG – Radio-over-Fiber (RoF) - Quality factor (Q) – Bit Error Rate (BER).*

1. Introduction

Currently, there is a huge need for communication services with very high bandwidths and higher service speed. Therefore, in front of this growing need, low-frequency communication bands are no longer in effect.

Wireless technologies generally operate in the frequency ranges around 2.4 GHz or 5 GHz, however these ranges are widely used around the world, making them highly saturated. The millimeter frequency band around 60 GHz has proven to be an effective solution thanks to its unlicensed band and worldwide availability, and has some other advantages, including a large bandwidth and high data rates of up to several Gigabits per second, allowing users to enjoy a very high connection speed. In addition, millimeter waves are quite attractive due to the possibility of reusing frequencies resulting from their attenuation as a function of distance, as well as the low interference due to other existing radio systems [1] [2].

On the other hand, millimeter waves suffer very high losses during their propagation in free space, in the order of 15 dB/Km, which considerably limits their transmission distance. For this reason, Radio-Over-Fiber technology has taken place as a powerful technology to avoid constraints and transmit the millimeter waves with very low losses through the use of the optical fiber characterized by a very high bandwidth, low losses and high transmission security [3] [4].

The generation of millimeter waves is carried out by many methods, mainly: Millimeter-wave generation by Direct and External Intensity Modulation [5], millimeter-wave generation by two lasers [6], and Millimeter-wave generation using a single intensity modulator [7]. In this paper, the generation of millimeter waves is achieved by the RoF technology based on the use of Bragg grating filters reflecting very specific frequencies [8] [9] [10] [11].

The schematic diagram of the proposed system is described in section 2. The simulations carried out are presented in section 3. Then, a conclusion is included in section 4.

2. System description

The schematic diagram representing the optical link simulated in this paper is shown in Fig.1. The wavelength spectrum emitted by a laser diode at a power of 20 dBm and a frequency of 193.1 THz, is injected into the input of the first FBG, which is a narrow-band filter allowing the reflection of a specific wavelength noted λ_1 ($\lambda_1 = 1553.8 \text{ nm}$). Then, the spectrum transmitted by the first FBG will be subsequently injected into the input of the second FBG, which in turn will reflect a second wavelength λ_2 ($\lambda_2 = 1553.3 \text{ nm}$).

A coupler is used to combine the two reflected wavelengths (λ_1 and λ_2) whose output is connected to an optical fiber that transmits them to a PIN photodiode placed at the system output. Finally, the optical signal corresponding to the two reflected wavelengths is visualized at the photodiode; where the difference between the two wavelengths is equal to 60 GHz. Therefore, a generation of 60 GHz millimeter waves is performed using the proposed system simulated with Optisystem software.

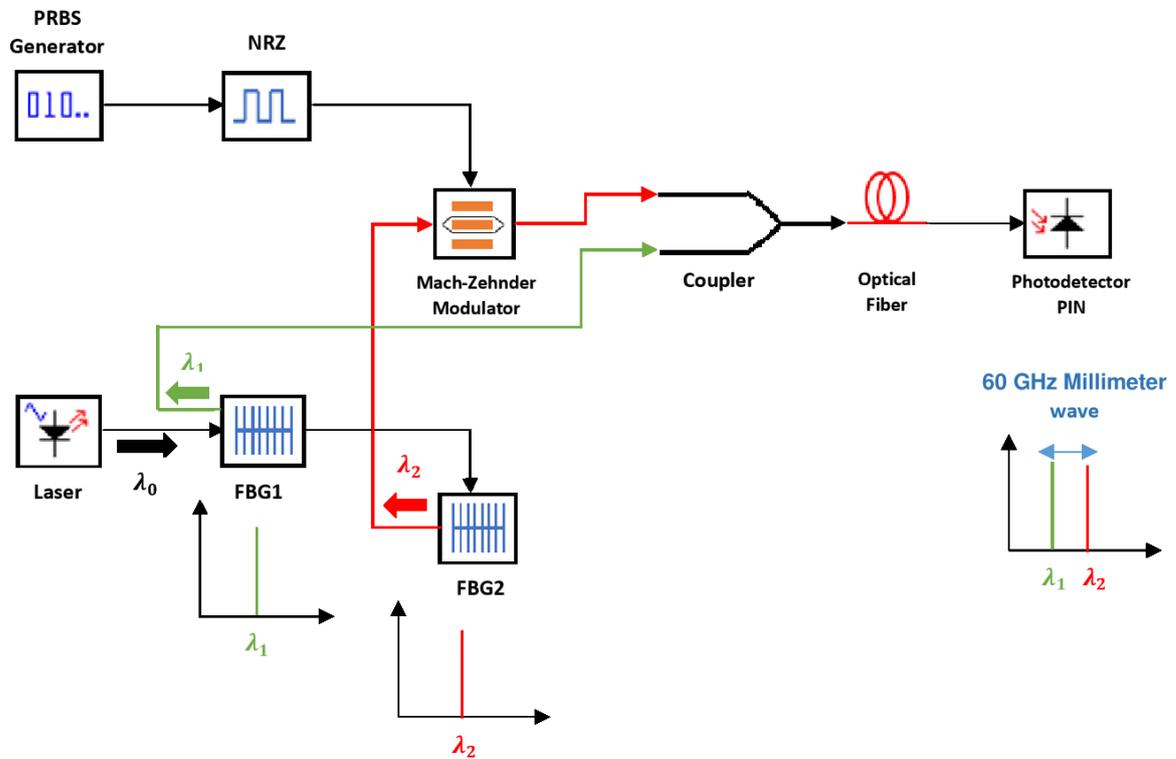


Fig.1. Schematic diagram of the simulated system for millimeter wave generation

3. Simulation results

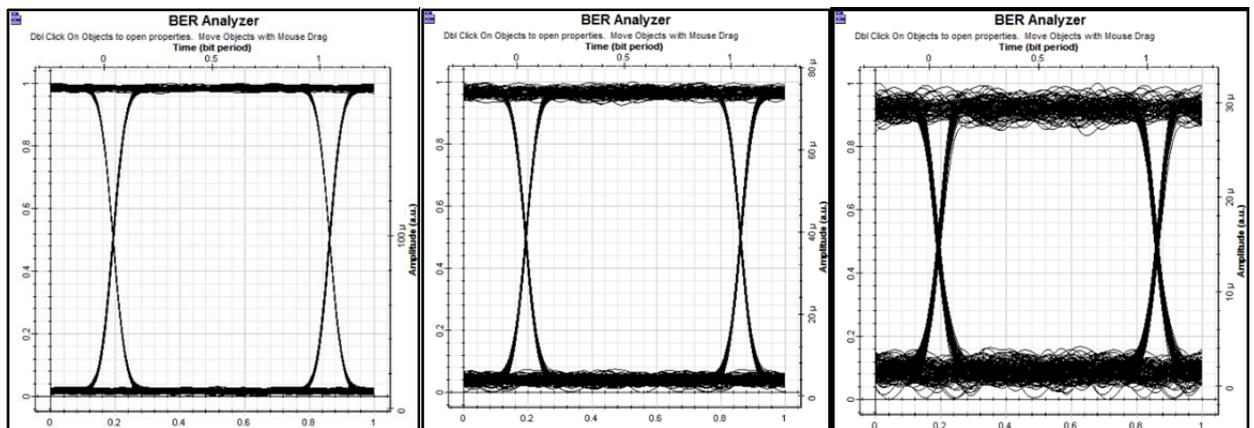
In this section, we present the results of the simulation performed using the proposed system described in the previous section, where the values of the used parameters are presented in the Table.1. The performance of the 60 GHz millimeter wave generation system is evaluated by studying the effect of the variation of optical fiber length on the eye diagram, the quality factor (Q) and the Bit Error Rate (BER).

<i>Parameters</i>		<i>Values</i>
PRBS Generator	Bit rate	1 Gbit/s
Diode laser	Frequency	193.1 THz
	Power	20 dBm
	Bandwidth	500 MHz
Mach-Zehnder modulator	Extinction ratio	30 dB
1st Bragg Filter	Frequency	193.07 THz
	Bandwidth	10^{-6} GHz
	Reflectivity	0.99
2nd Bragg Filter	Frequency	193.13 THz
	Bandwidth	10^{-6} GHz
	Reflectivity	0.99
Optical Fiber	Loss	0.2 dB/Km
	Dispersion	16 ps/nm/Km
Photodetector	Responsivity	1 A/W
	Dark current	10 nA

Table.1. Parameters' values used in the simulation

3.1. Effect of optical fiber length on the eye diagram

In this section, we evaluate the proposed system performance by varying the optical fiber length while visualizing the eye diagram for each length. The bit rate is set at 1 Gbit/s, the power at 20 dBm and the FBG bandwidth at 0.6 nm. As shown in Fig.2, it is clear that the opening of the eye diagram for short lengths of optical fiber is better than that for long lengths. As the length increases, the eye closes more and more. The opening of the eye diagram remains good for optical fiber lengths up to 70 km. From this length, the clarity of the eye deteriorates and the transmission quality no longer remains good.



(a)

(b)

(c)

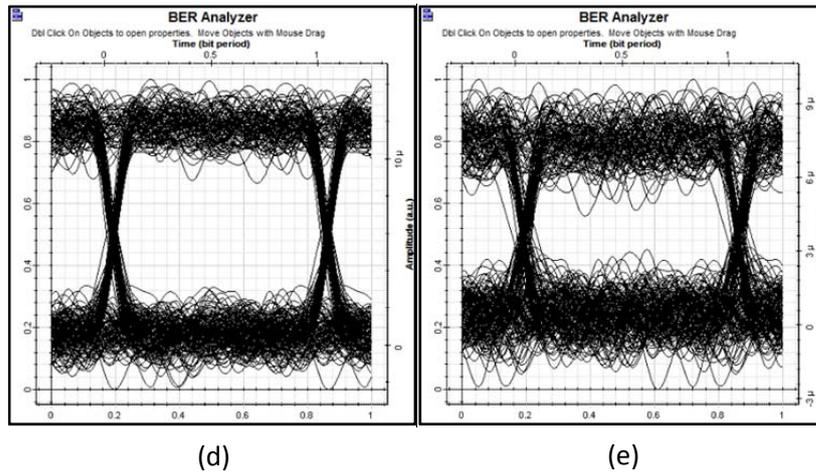


Fig.2. Eye diagram for (a) L= 10 Km, (b) L= 30 Km, (c) L= 50 Km, (d) L=70 Km and (e) L=80 Km with D= 1Gbit/s and P= 20 dBm.

3.2. Variation of the quality factor Q and the bit error rate BER as a function of the optical fiber length

In this section, we are interested in the effect of fiber length on the quality factor Q and the bit error rate BER. As shown in Fig.3, the quality factor reaches its maximum at a distance of 10 km, and then as the length increases, the signal quality deteriorates. In addition, above 80 km, the quality factor Q reaches almost null values.

Similarly, Fig.4 shows the variation of the BER as a function of fiber length. It is clear that the BER is almost zero for all lengths less than 70 km. From this length, the BER is no longer acceptable because its value exceeds the tolerated value, which is in the order of 10^{-9} . For example, the BER corresponding to 70 Km is 8.0734×10^{-14} , while for a distance of 80 km, the BER is about 1.23×10^{-6} .

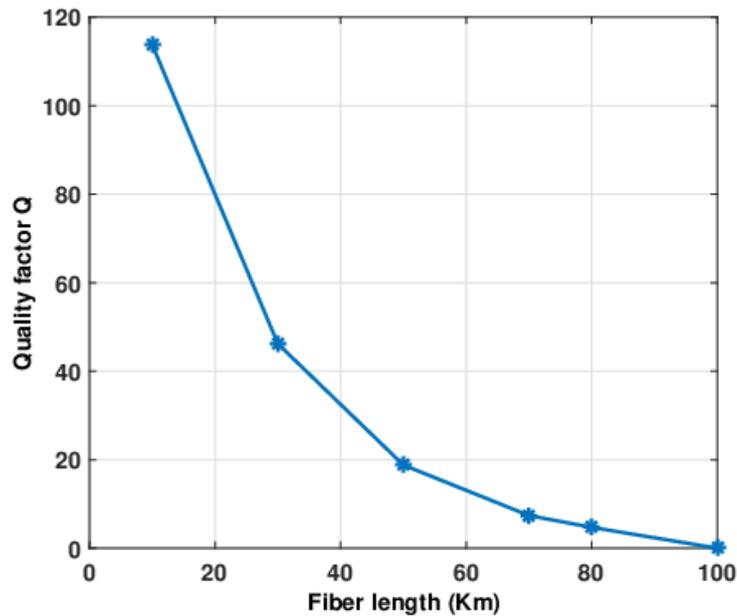


Fig.3. Variation of the quality factor Q as a function of the optical fiber length

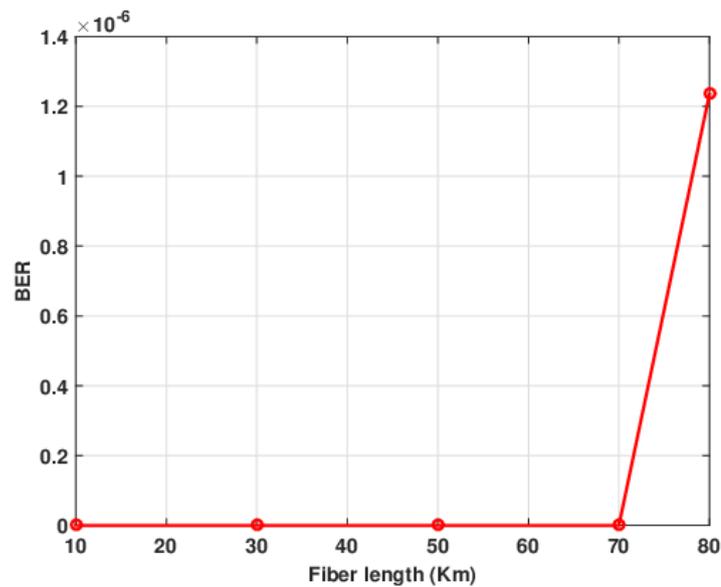


Fig.4. Variation of the bit error rate BER as a function of the optical fiber length

4. Conclusion

A new technique for millimeter wave generation using a RoF system based on narrow band Bragg filters has been proved in this paper. The simulations performed show that the transmission quality of the proposed system is influenced by varying the optical fiber length. The obtained results display that the eye diagram remains clear for fiber lengths up to 70 km and that the Quality factor (Q) and the Bit Error Rate (BER) also take an acceptable value. The proposed system in this paper can also be effective for long transmission distances by connecting, for example, several fibers with a length of 70 km.

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